

Policy Issues on White Roofs: Heat Islands, Public Health, and Global Warming

Discussion with Indian Electricity Regulators
UC Berkeley Faculty Club
July 10, 2013

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The July 1995 Chicago heat wave resulted in 739 reported* deaths

- The highest risk group lived on the top floors of buildings with black roofs



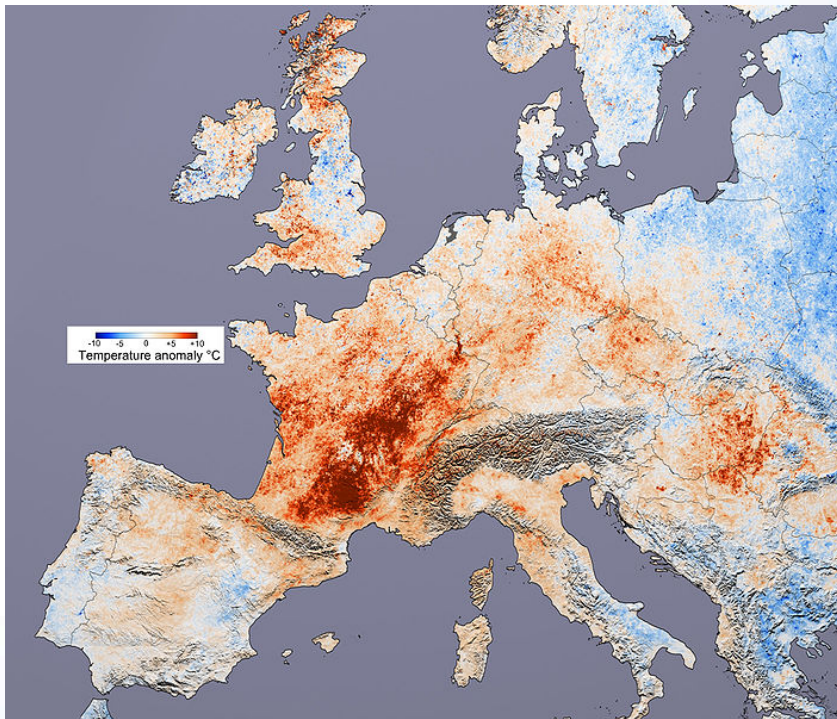
Photo credit: Gary Braasch

*More than 250 additional deaths not autopsied



The August 2003 European heat wave killed 52,000 people

- Temperature anomalies reached 10°C
- 18,000 Italians died (2006 assessment)



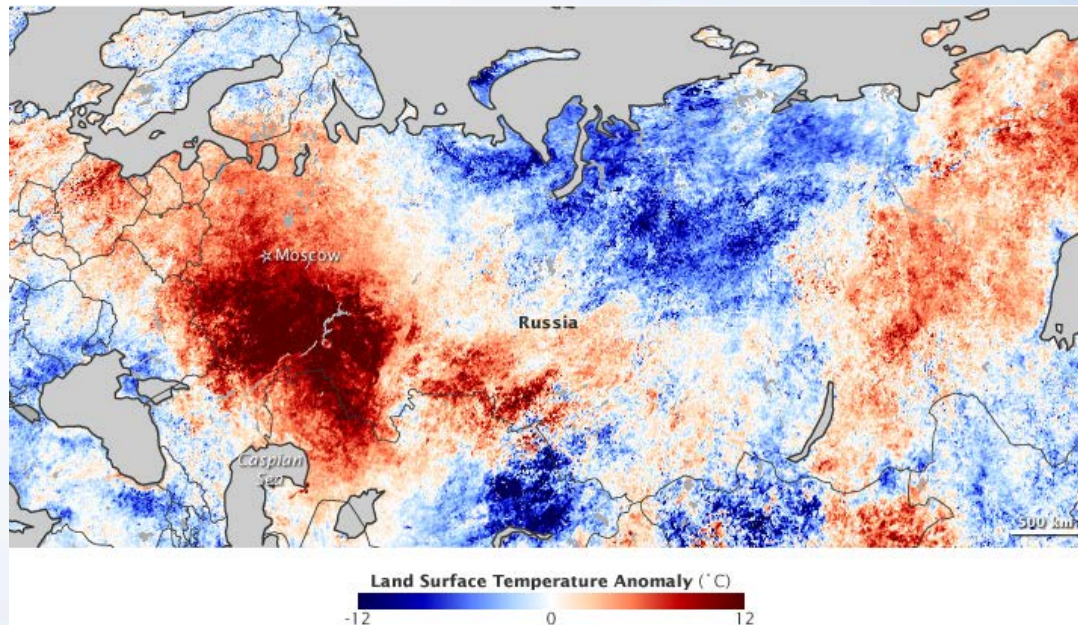
<http://earthobservatory.nasa.gov/IOTD/view.php?id=3714>

Country	Fatalities
Italy	18,257
France	14,802
Germany	7,000
Spain	4,130
England & Wales	2,139
Portugal	2,099
Smaller countries	4,025
Total of above	52,452



The 2010 Russia heat wave caused 10,000-15,000 deaths

- Centered Southeast of Moscow
- Temperature **anomalies** reached 12°C



<http://takvera.blogspot.com/2011/10/climate-change-fractional-attribution.html>

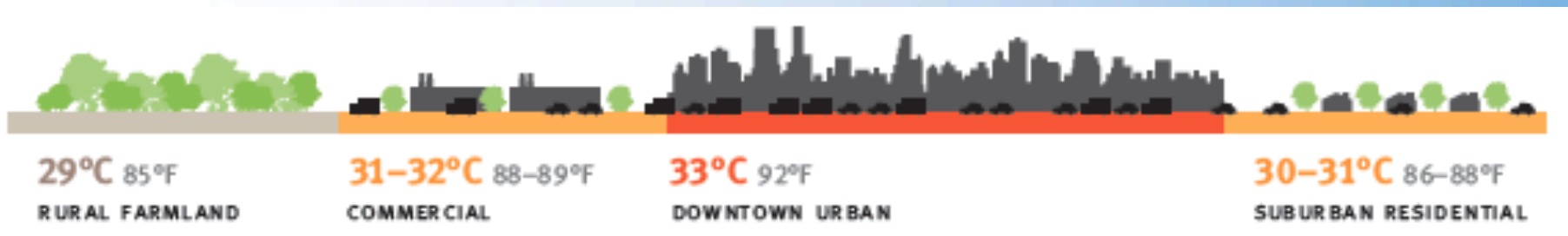
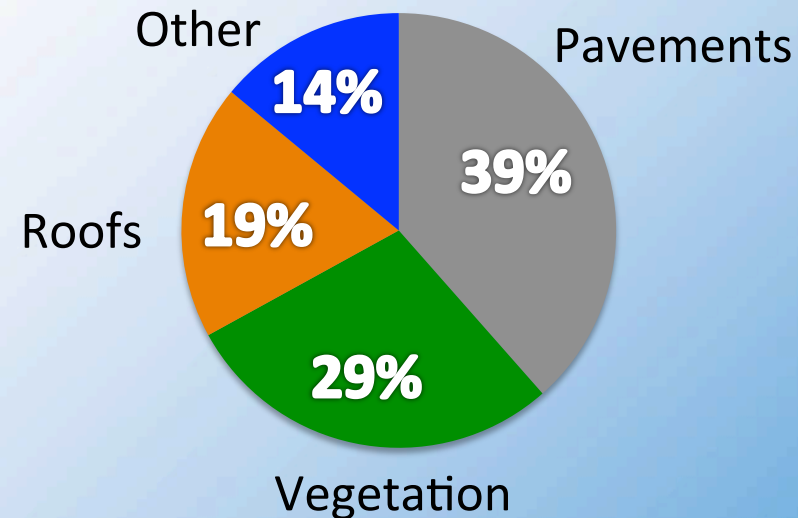


Human activity + dark roofs and pavements combine to heat urban air

The “urban heat island effect”:

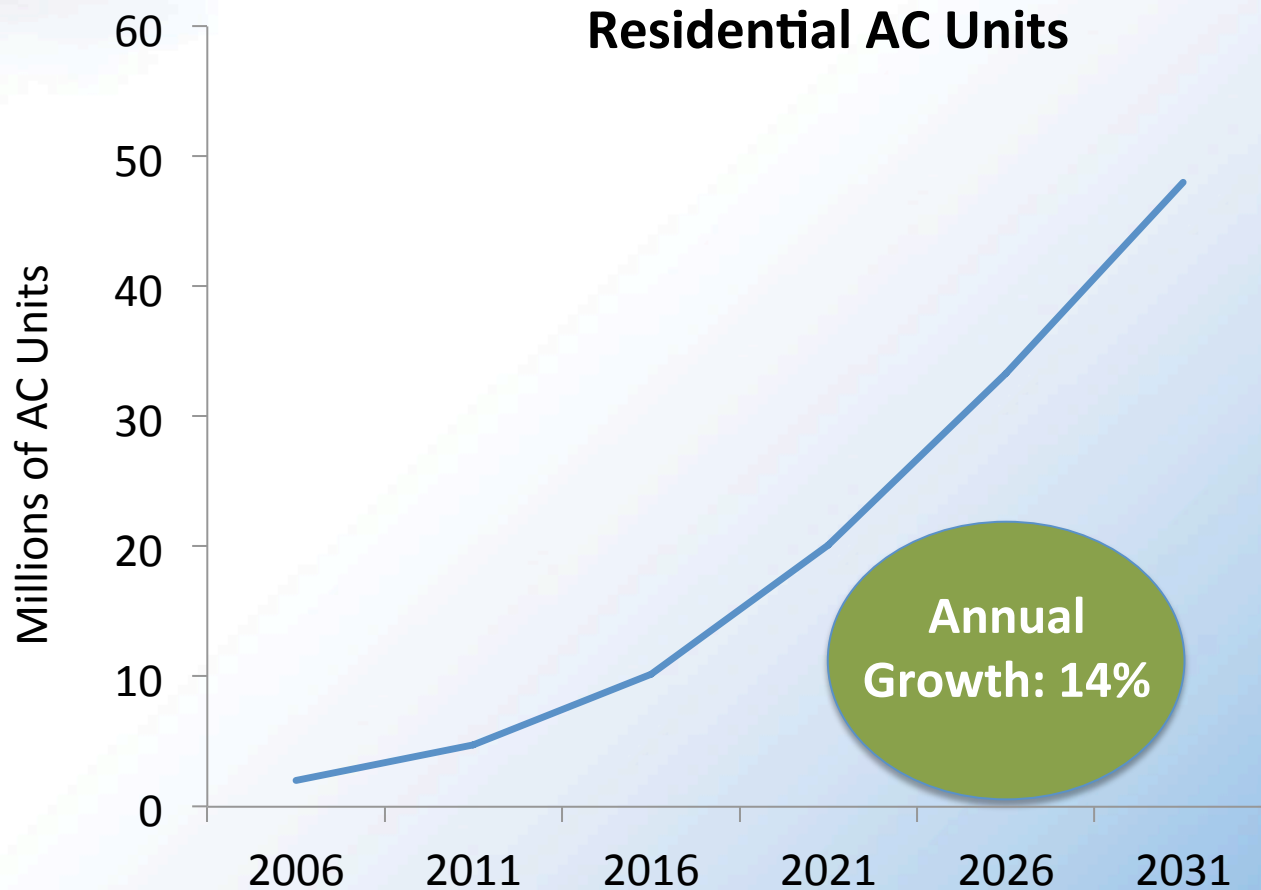
- Makes cities hotter than surrounding rural areas
- Leads to greater energy use, worse air quality, and reduced quality of life

Urban fabric above tree canopy





Air conditioning is projected to continue its rise in India



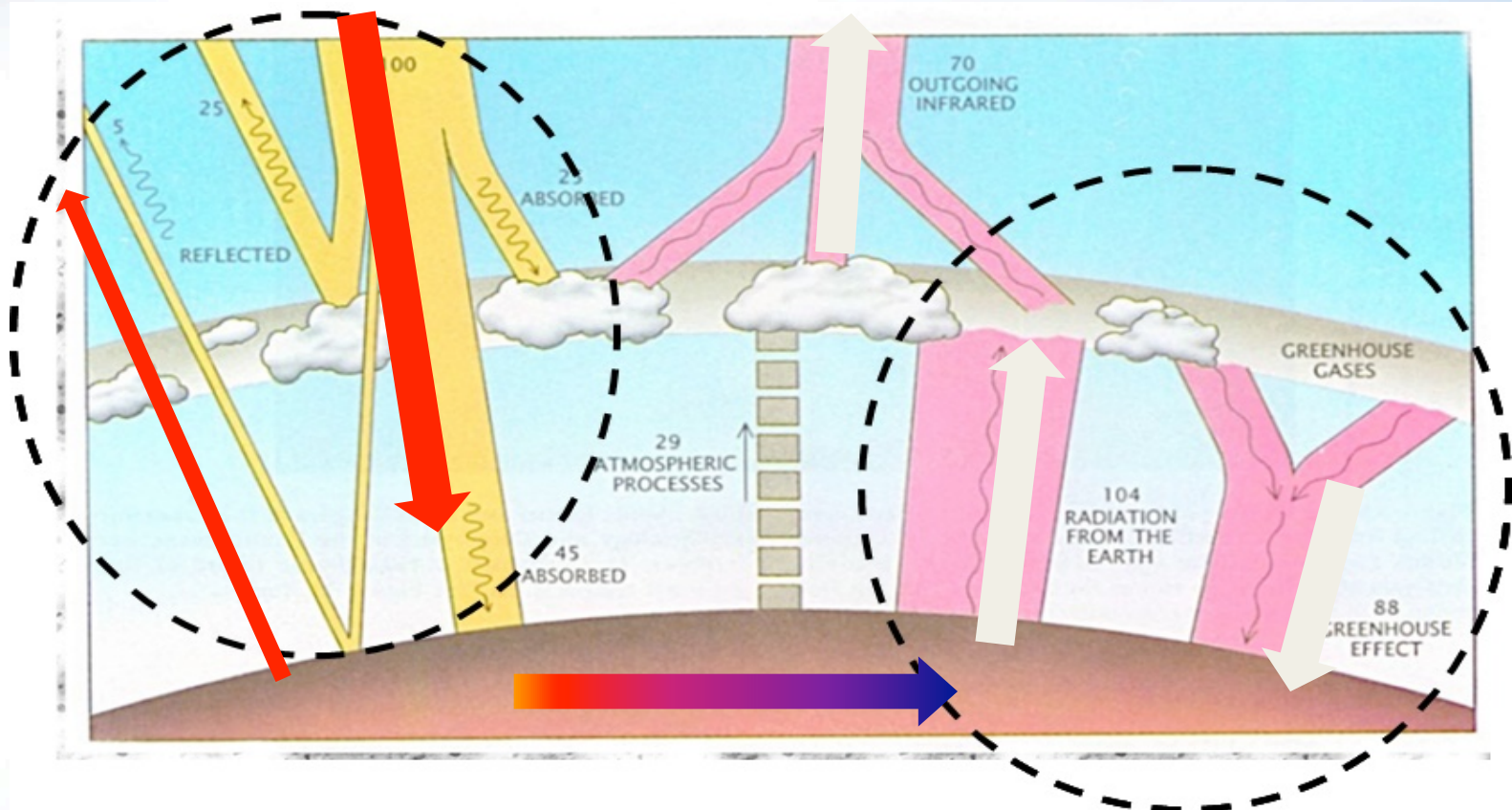
Source: World Bank



Cooling our Planet



Solar-reflective surfaces cool the globe via “negative radiative forcing”



Source: Intergovernmental Panel on Climate Change (IPCC)



Whitening 100 m² of gray roofing cancels out the emission of **10** tons of CO₂





Whitening all eligible urban flat roofs worldwide offsets **24** Gt CO₂e

- Over 20 years (the life of a roof) this is ≈ 1.2 Gt/yr
 - 2/3 of a year's worldwide emission
- Equivalent to **taking half the cars in the world off the road for 20 years**
 - There are about 600 million passenger cars worldwide, each emitting ~ 4 t CO₂ / yr





Full white roof potential avoids **500** medium-sized coal-fired power plants



= 100 coal-fired plants

- Equivalent to **1,000** medium-sized gas-fired power plants
- Globally, power plants emit ~15 Gt CO₂ each year
 - Amounts to **6,000** typical midsized power plants (2/3 coal, 1/3 gas)



For comparison, CFL deployment avoids emissions from **400** power plants



= 100 coal-fired plants



Addressing urban heat islands also achieves urban resilience and global sustainability

Building scale



- Up to 20% reductions in cooling demand on top floor
- Improved thermal comfort and productivity in unconditioned buildings (e.g., homes, warehouses etc.)
- Longer lasting roofs

City scale



- Improved air quality – a \$10 billion energy and health cost reduction opportunity in the U.S. alone per year
- Reduced peak electricity demand and avoided adoption of air conditioning
- Greater resiliency to heat events and climate change

Global scale



- Offset the warming effect of 24 gigatons of CO₂ – equivalent to taking 500 coal power plants offline for 20 years
- Every 10 square meters of white roof = 0.5 tons of CO₂ offset per year



White Roofs Around the World



Almeria, Spain provides a real-world example of cooling from white roofs



The whitewashed greenhouses of Almeria, Spain have cooled the region by 0.8 degrees Celsius each decade compared to surrounding regions, according to 20 years of weather station data.

Source: Google Earth



White roofs have long been common practice in Santorini, Greece





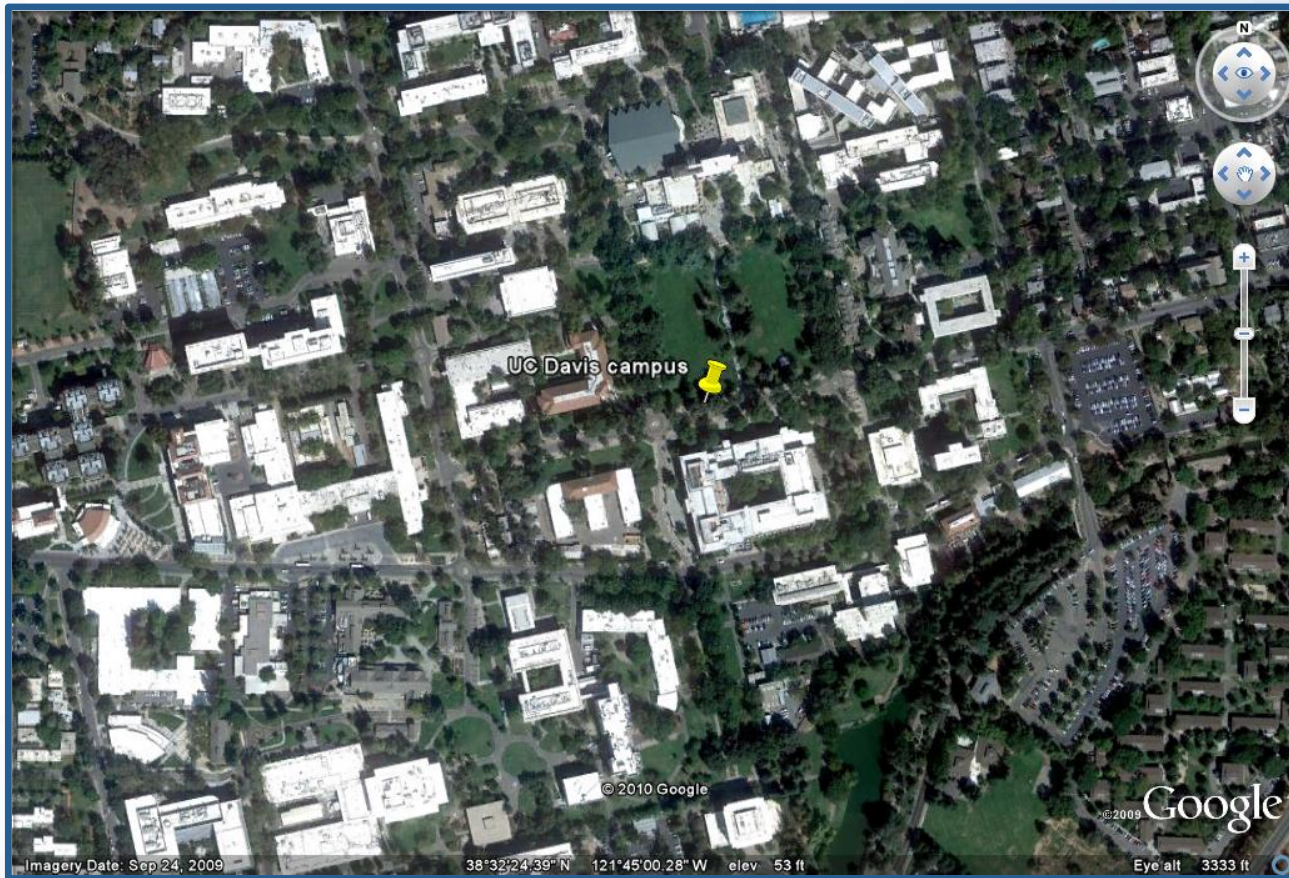
...and in Hyderabad, India



Widely
accepted
in the state of
Gujarat, India.



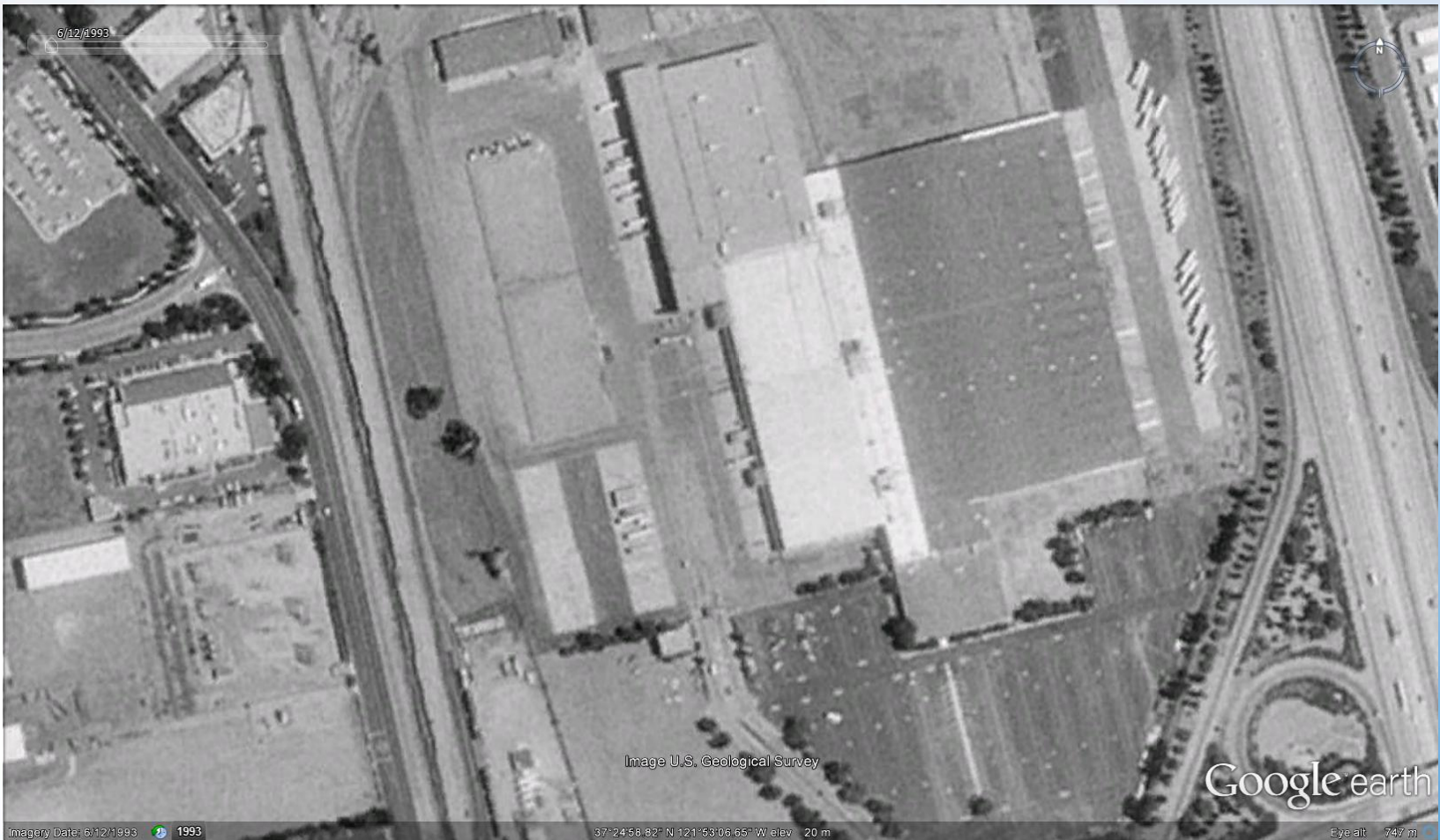
UC Davis switched to white roofing membranes circa 1980



...and some are still in service today

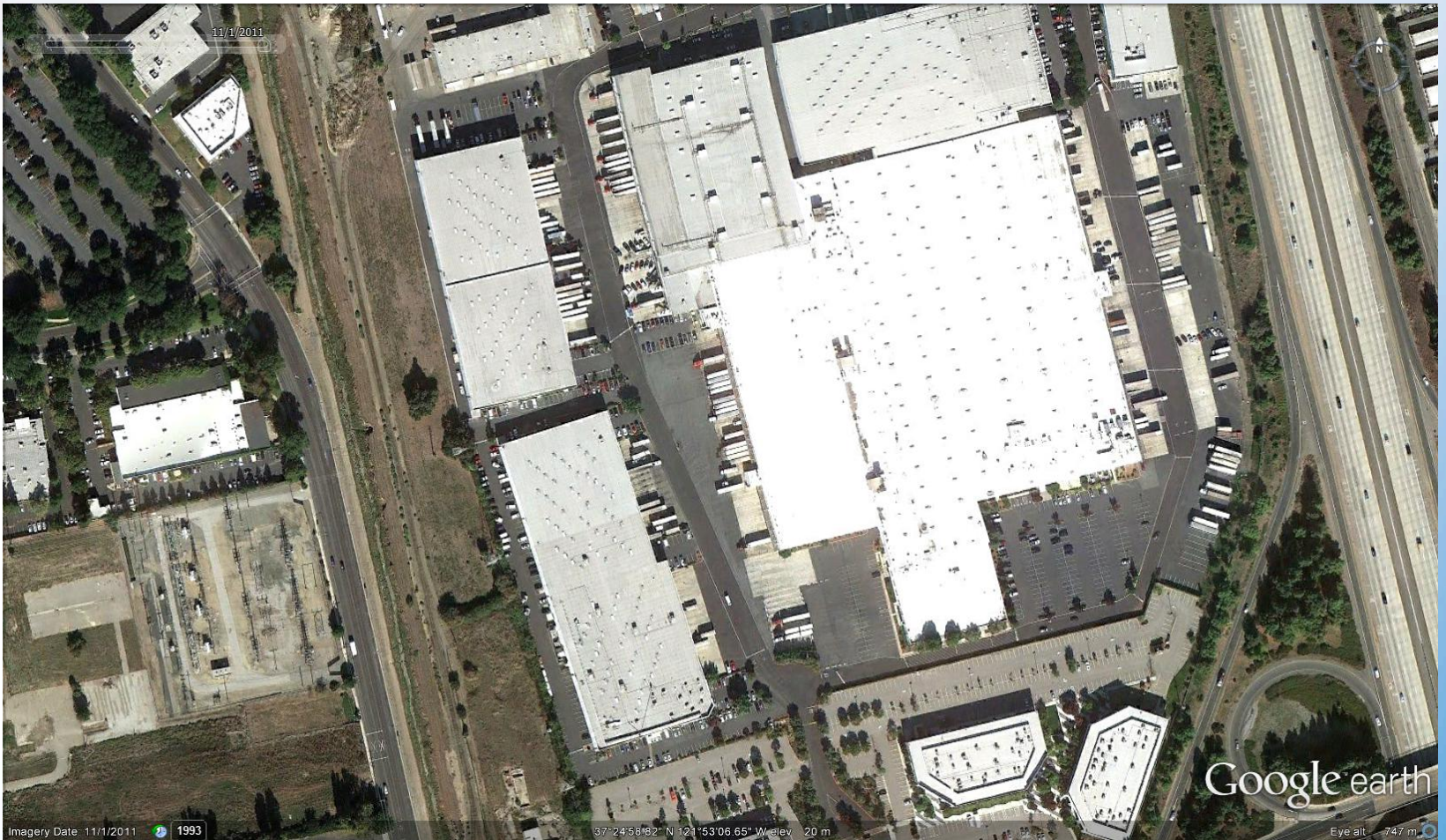


San Jose, CA in 1993 (pre-Title 24)





San Jose, CA in 2011



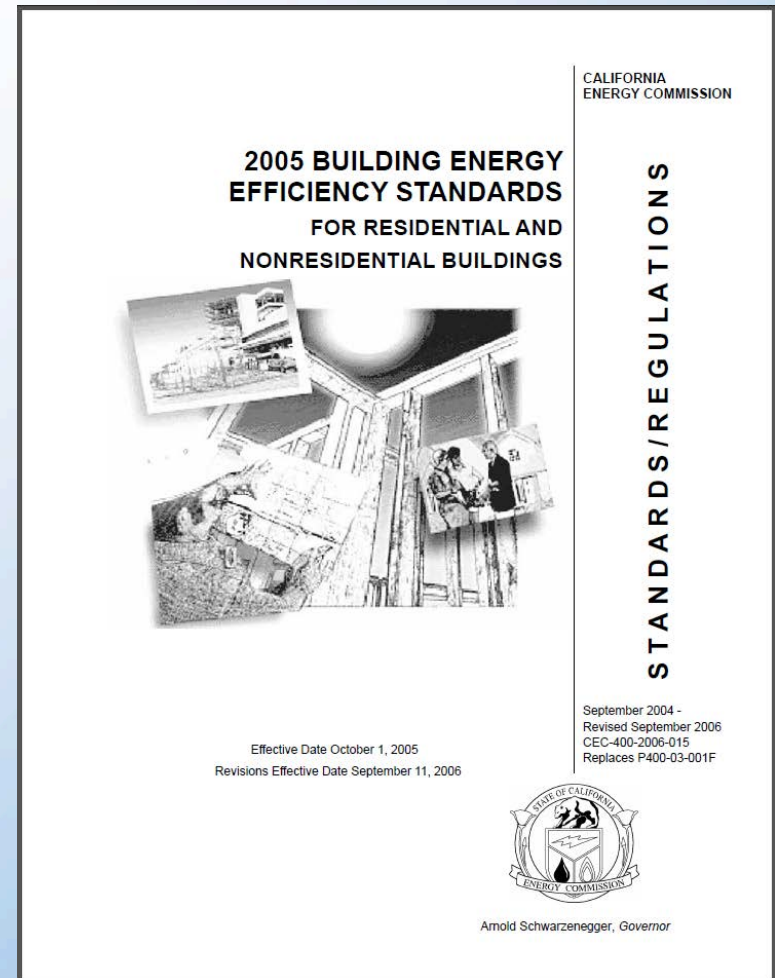


What to do Now



Energy efficiency standards have made great strides, in CA and elsewhere

- 2005: CA's "Title 24" prescribed white surfaces for low-sloped roofs
 - Model codes (ASHRAE, IECC), some hot states and cities have followed
- 2008: Title 24 prescribed "cool colored" surfaces for steep roofs in 5 hottest climate zones
 - Not yet in effect for Los Angeles





Timeline of recent cool roof progress (2005 – 2012)

- 2005
 - California Title 24 – “Flat roofs shall be white” (15 out of 16 climate zones)
 - Walmart adopts white roofs for all stores
 - EPA ENERGY STAR lists cool roof materials
- 2010
 - June 1st, 2010 – Memo from U.S. Energy Secretary Steven Chu calls for all DOE buildings to have white roofs, if cost-effective
 - June 16th, 2010 – Marine Corp follows suit, Pentagon GSA following
 - June 19th, 2010 – *RetroFIT Philly* announces winner of “coolest block” contest to white-coat black roofs of row houses
- 2011-12
 - 100 Cool Cities launched – see GlobalCoolCities.org
 - 2012--US launched, at G20 Energy Ministers meeting, a voluntary Cool Roofs Working Group, and offers technical assistance to “charter” developing countries: India, Japan, Mexico, & US joined (further discussions with Brazil, China, South Africa)
 - New York City and Chicago adopt “If it’s flat it shall be white or green”



Resources on the web

- LBNL – Heat Island Group
 - HeatIsland.LBL.gov
- Global Cool Cities Alliance
 - GlobalCoolCities.org
- Cool Roofs and Cool Pavements Toolkit
 - CoolRoofToolkit.org
- Art Rosenfeld's website
 - ArtRosenfeld.org



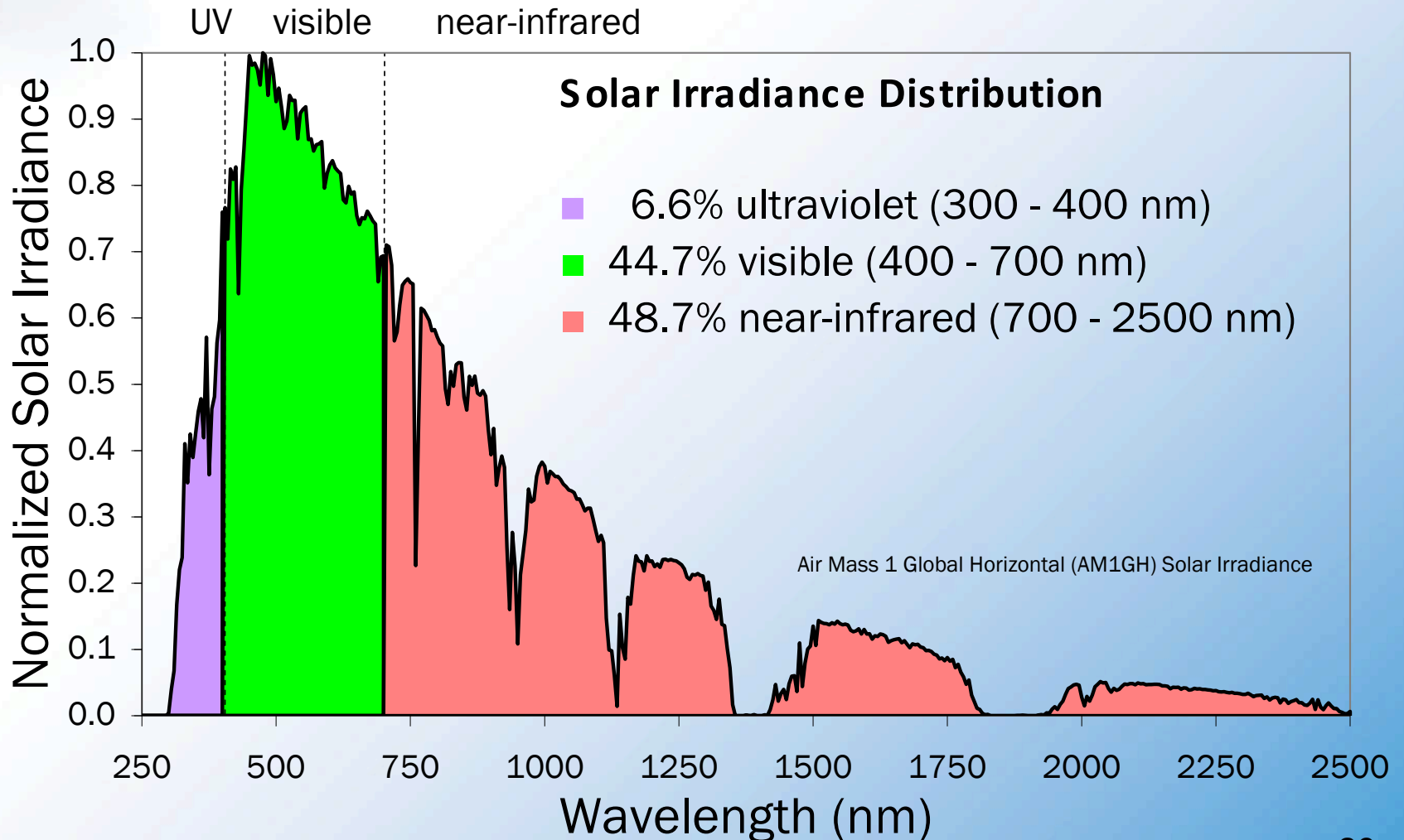
LAWRENCE BERKELEY NATIONAL LABORATORY PRESENTS:
SCIENCE AT THE THEATER

COOL CITIES, COOL PLANET

Cool Colors

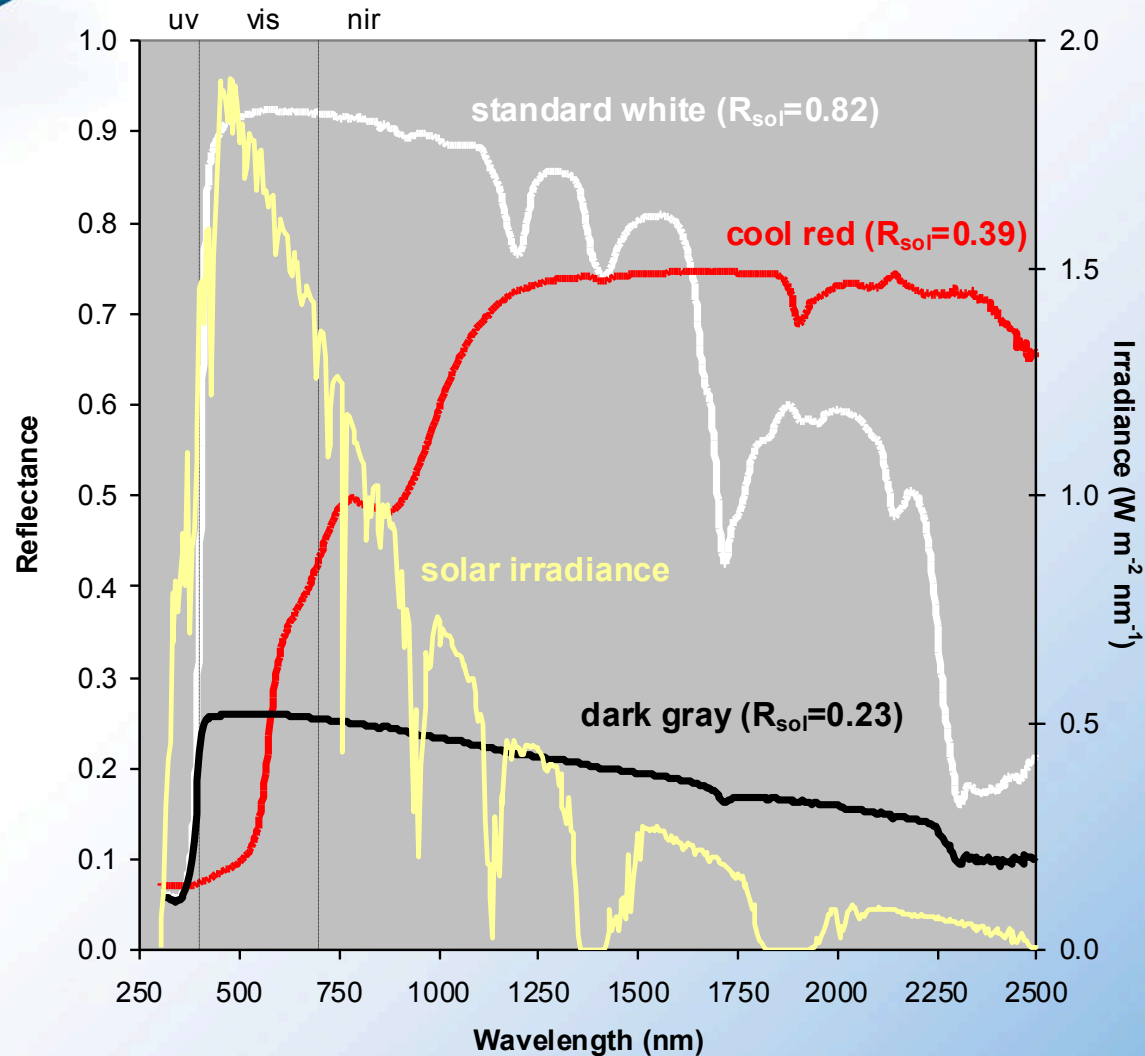


Sunlight is more than meets the eye





Cool roofs can be white or “cool colored”



white roof



cool red roof



gray roof



Cool-colored roofs are available in many materials and colors

<p>cool concrete tile SR ≥ 0.40</p> <p>standard concrete tile (same color)</p>						
	R=0.41	R=0.44	R=0.44	R=0.48	R=0.46	R=0.41
	black	blue	gray	terracotta	green	chocolate
	R=0.04	R=0.18	R=0.21	R=0.33	R=0.17	R=0.12
solar reflectance gain =	+0.37	+0.26	+0.23	+0.15	+0.29	+0.29

Courtesy
American
Rooftile
Coatings

cool clay tile
SR ≥ 0.40

Courtesy
MCA Clay Tile



cool fiberglass asphalt shingle

SR ≥ 0.25

Courtesy
Elk Corporation

Concord Green 81214 87.3 (91.4)	State Gray 81208 39.7 (9.5)
Riverdale 81216 57 (47)	Bright Red 81246 38.5 (28.5)
Santa Tan 81217 58.8 (27.5)	Brick Red 81246 38.8 (24.7)
Pearl Gray 81204 45.7 (31.5)	Medium Bronze 81211 34.8 (12)
Marine Green 81202 41 (21.8)	State Blue 81206 34.4 (21.3)
Patina Green 81205 41 (29.2)	State Bronze 81215 32.8 (9.8)

cool metal
SR ≥ 0.30

Courtesy
BASF Industrial
Coatings